Heart and Blood Vessels in the Young.

BY

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Address before the Association of the Alumni of the Long Island College Hospital, Feb. 27, 1888.

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HEART AND BLOOD VESSELS IN THE YOUNG.

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The blood of the advanced fœtus and newly born is more concentrated than that of the mother. It contains mainly more hæmoglobin; therefore, according to the simple rules of osmosis, a surplus will pass from the maternal vessels of the placenta to the fœtal. These, when entering the fœtus, will leave some of the blood introduced and required for the development of the fœtus in its tissues. Thus it is certain that the two umbilical arteries cannot export so much blood as the single vein imports.

The hæmoglobulin of the blood contained in the umbilical artery amounts to 22.2 per cent. of the whole quantity of solid constituents, while in the venous blood of the mother it is but 13.99 per cent. The first to prove this high percentage was Denis, who found in 1830 the correct proportions by determining the quantity of iron contained in the blood.

No less is the blood of the newly born different from that of the

adult and even the infant. Poggiale studied hæmoglobulin in the newborn and the full grown dog, and found 16.5 in the solid constituents of the blood of the former compared with 12.6 per cent. in that of the latter. Wiskeman's results are similar. It is only in advancing age that the hæmoglobin which rapidly diminished in infancy, begins to increase again, but it does so slowly. In calves and oxen the proportion is 11.13:13.21 per cent. Denis found it diminishing until the age of six months, and increasing slowly up to the thirtieth year. Leichtenstern found the following proportions: If the blood of the newly born contain hæmoglobulin 100, that of a child of from six months to five years contains 55; of from five to fifteen years, 58; between the ages of fifteen to twenty-five, 64; from twenty-five to forty-five, 72; from forty-five to sixty, 63. (Subotin also found less in young animals than in old ones; also less when the amount of nitrogenous food was diminished.) The percentage of hæmoglobulin decreases mostly in the very first two weeks. It is lowest at the age of from six months to six years; after that time a slow increase is taking place. But even in the very vigor of life, in the third and fourth decades, the percentage of hæmoglobulin is smaller than in the newly born.

There are some more differences, depending on age, in the composition of the blood, more or less essential. The fœtal blood and that of the newly born contain but little fibrin, but vigorous respiration works great changes in that respect. Nasse found the blood of young animals to coagulate but slowly. How this is in the infant, cannot be determined until more and better observations will have been made. It has struck me, however, in many instances of cerebral apoplexy of the newly born that the time for coagulation of the blood must be longer than in adult; for the hæmorrhages are apt to be most extensive in the infant. In the sanguineous tumor, kephalhæmatoma, of the newly born, the blood remains liquid in the sac for many days, and not uncommonly will, in apoplexy, spread all over the hemispheres, have plenty of time to perforate and penetrate the pia in all directions, destroy most of the cerebral tissue, and flow down the spinal cavity. These occurrences are so frequent in the infant, and so rare in the apoplectic adult, that they can hardly be explained except through the insufficient coagulability of the fœtal and infant blood.

There are less salts in the blood of the young, and, according to Moleschott, more leucocytes. Its specific gravity in the young is 1045-1049; in the adult, 1055. At the same time it is important to recollect that the total amount of the blood contained in the newly born is smaller in proportion than in the adult, the relation of its weight to the total weight of the body being in the former, 1:19.5; in the latter, 1:13.

The brief results of the above statements are as follows: The young infant (and child) has less blood in proportion to its entire weight; this blood has less fibrin, less salts, less hæmoglobulin (except the newly born), less soluble albumen, less specific gravity, and more white blood corpuscles than the blood of advanced age. While these facts may require a few considerations later on, a single remark may be bestowed on one of the results of an undue amount of blood in the circulation of the newly born.

Weber and Hewitt look for the explanation of many cases of icterus in the newly born in the condition of the hepatic circulation. When the lungs are in a more or less atelectatic condition, the liver is in a state of passive congestion. Then the dilated vessels compress the biliary ducts. The same result, that is, jaundice in the newly born, is accomplished by an overdue amount of blood in the general circulation. When the mass of blood circulating in the newly born has been increased by pressing out the placenta, and applying the ligature late, jaundice will follow.

The function of the heart begins in the third week after conception. Its beats are very irregular at first, become soon regular, but remain very frequent until birth. As late as 1822, a surgeon of Geneva, Switzerland, Mayor, utilized the knowledge previously obtained, of the existence and audibility of fœtal heart beats for a practical purpose. Until that year no obstetrician knew whether the fœtus during parturition was still alive or already dead, and the indications for accelerating delivery because of danger to the fœtal life did not exist. At a later period, it was Frankenhäuser who tried to predict the sex of the infant by counting the number of the fœtal heart beats before birth, or rather before labor pain had commenced. He believed to have found that a fœtal pulse, when nearer 124 than 144 in a minute, belonged to a male child, and *vice versa*. I fully believe he was not so often mistaken, as his successors assumed. In a great many cases his experience holds good, but the examination must be made before labor sets in, and in an afebrile condition of the mother. I know that when I still attended a great many obstetrical cases, many years ago, I was seldom mistaken in the prediction, based on Frankenhäuser's principle, of the sex of the child, provided I did not make my examination when the pulse was disturbed by causes due to changes in either the fœtus or mother.

The absolute weight of the heart, at different ages, has been studied by many observers, mostly by Boyd, who published his investigations in 1861. They refer to 1,007 males and 1,038 females in Marylebone Infirmary, and 295 males and 233 females in the Insane Asylum of Somerset, and extend over the nine years from 1839 to 1847.

The weights of the heart are, mostly according to Boyd :

In the new-born,	- - -	20.6 grammes.
1½ years,	- - - -	44.5 "
3 "	- - - -	60.2 "
5½ "	- - - -	72.8 "
10½ "	- - - -	122.6 "
17 "	- - - -	233.7 "
24.5 "	- - - -	270.6 "
35 "	- - - -	302.9 "
41–50 "	- - - -	303.0 "
51–60 "	- - - -	316.6 "
61–70 "	- - - -	331.8 "
71–80 "	- - - -	320.8 "
81 "	- - - -	303.5 "

Thus the proportion of the weight of the heart to that of the body exhibits no extraordinary differences in the several ages; and the mechanical labor required to supply the body, or any part of it, with blood is therefore about the same in the young or old. Still there are differences. The yearly increase of the weight of the heart is largest in the first few years during the most intense growth, a little less about the fourth and fifth years, and again larger about the period of puberty. After this time the annual increase becomes smaller, still it continues until the time of senility. The absolute weight increases until the seventieth or eightieth years, after which it decreases a little, always provided that the atheromatous changes in the arteries, which occur more or less normally about and after the fortieth years, are not of such an importance as to result in hypertrophy of the heart.

Though the limited time at my disposal cannot permit me to refer extensively to the literature of the subject, my account would be quite incomplete if I did not allude to at least a single book which, by its immense material and careful sifting, has vastly added to our knowledge. I speak of W. Müller's treatise on "The Proportions of the Volume of the Human Heart," 1883. From the large amount of information contained on its 220 pages, I give a few points full of suggestions.

The absolute and proportionate weight of the heart of the embryo is very great. As soon as the extensive circulation of the allantois ceases, the heart of the embryo increases rapidly. It has not only to supply the growth of the body to which it belongs, but also the cord and placenta. Thus the increase in weight of the heart is mainly perceptible in the first half of embryonic life without any difference as to sex. The latter does not show its influence before the completion of

the fifth year. Though, however, the increase of the heart is mainly noticeable in the earlier months of embryonic existence, it is quite marked in the later period also, for it is at this time that the permanent organs of the body come in with their claims on circulation and nutrition. Thus the proportion of the heart to the rest of the body is largest about the time of birth, remains stationary for a little while, and takes a new start about the end of the second or during the third month with the greater extent of the surface of the infant body. The increase in weight is mainly confined to the ventricles, for the auricles lose in proportion to the ventricles up to the period of completed development of the adolescent. At that time the auricles begin to increase noticeably. Still, though the relative weight may diminish, their absolute weight is growing constantly during life. In the embryo it is the muscular mass of the right auricle which predominates over the left. From the beginning of the second month after birth, and during the whole of the first year, the right and left auricles are equal. After that time the right auricle continues to outrank the left, so that during and after puberty its weight is larger by 5.5 per cent. The right ventricle is extremely active during its embryonic development, because of the existence of the placentar circulation, the accumulation of large quantities of blood, and the patency of the foramen ovale through which large amounts of blood are repelled into the right heart. The equality of both auricles during infant life is due to the absence of great muscular exertions, and the renewed increase of the right auricle during later life to the effect of muscular action on the distribution of the blood.

The proportion of the size and weight of the heart to the body at large is about the same in the later months of the fœtus and the earlier of the infant. But the relations of the right and left ventricles to each other become greatly altered immediately after birth. This change is very marked during the first two weeks. Its cause is evident. It is true the heart is relieved in the moment of birth of its placentar circulation, and by the large amount of blood aspirated by the lungs which begin their life-long work ; but this relief—which remains permanent for the right ventricle—is outbalanced for the left ventricle by the organs of the body, whose claims on the action of the heart are either increased—thus intestines and the large glands, also the kidneys and nervous system—or entirely new, like the skin with its new function of radiation, and the respiratory organs with their rhythmical motion. The effect on the function of the left ventricle, and its increase in size, becomes particularly great when the involution of the ductus arteriosus Botalli has become perfect after the first month. The relation between the right ventricle and the left becomes permanent about the time of

erect walking. At that time, and later, and without difference as to sex, the proportions of the former to the latter is as 507 to 1,000; that means the right ventricle has half the weight of the left.

What I said of the predominance of the right heart over the left during fœtal life, a predominance which is the result of the right heart being the principal motor in fœtal circulation, gives the simple clue to the fact that its physiological action is liable to become pathological. The large majority of fœtal diseases of the heart are met with in the right auricle and ventricle. It is only after birth, and mainly in advancing years, when the physiological predominance of the left heart has become established that in it cardiac disorders are almost exclusively found.

The normal proportion of the weight of the right and left heart—507 : 1,0 0—is disturbed by such morbid conditions only, which terminate in unilateral or bilateral actual hypertrophy. This is by no means rare in children; for acute endocarditis and acquired valvular diseases are with them quite frequent. If, in your experience, it has struck you that they are often encountered about the fifth year, I beg you will remember that this is exactly the time in which the growth of the child's heart has become temporarily less, and the disproportion between its size and the claims to be satisfied—that is, the necessities of circulation and nutrition—are quite as urgent as before.

However, the temptation to make the diagnosis of cardiac hypertrophy is still greater than its actual occurrence; for the heart's dullness is liable to be extensive under normal circumstances.

In twelve healthy children of from three to eight years, Gerhardt found the cardiac dullness almost as large as in adults; that is, longitudinally, along the margin of the sternum, 4½ centimetres; transversely, 5 centimetres. Dullness commenced about the third or fourth rib, its height equalled half the length of the sternum; the impulse was often found beyond the mamillary line, and not infrequently in the fourth intercostal space, for the diaphragm stands higher in children than in adults. Thus the absolute cardiac dullness is proportionately larger and higher, the reverse of what is found in old age. This is most perceptible about the sternum. Along its right margin the cardiac dullness is very much more marked in children than in adults. Its location is changed by turning the child on its side, but not by its sitting up or lying down. It is particularly the inferior margin of the dullness which is not altered by changes of posture.

Abnormal shapes of the thorax are frequent causes of increased dullness. As soon as the shape of the chest ceases to be elliptical, and becomes quadrangular or triangular in consequence of previous pleuritic adhesions or rhachitic deformity, the heart touches a level surface

instead of an arch, its dullness is apt to give the impression of enlargement, and its more distinct impulse that of hypertrophy.

Diminution or complete absence of cardiac dullness in its normal location is found in different conditions: when the heart is congenitally situated in the right half of the chest; when there is, on the left side, pneumothorax with enlargement of thoracic cavity and changes in the location of neighboring organs; in emphysema; in pneumopericardium.

Though I am not permitted, in the limited time at my disposal, to lose myself in the consideration of pathological subjects, I still believe that the allusion to a few anatomical differences in the heart of early infancy and more advanced age has been found acceptable. Such differences are, however, not confined to the heart; the blood vessels share in the peculiarities which render the study of the fœtus, infant, and child so interesting. It is in the observation of gradual development, and the kaleidoscopic changes of lively growth, wherein lies the greatest fascination.

Quite an abnormal position is reserved by nature to the blood vessels connecting the mother and fœtus in the umbilical cord. They are two arteries and one vein. The former are the continuations of the two hypogastric arteries which ascend—along the urinary bladder—to the anterior abdominal wall, in the loose connective tissue of which they finally reach the umbilical ring. The vein originates in the placenta, runs within the cord in spiral convolutions, passes the umbilical ring, attaches itself to the loose connective tissue of the anterior aspect of the ligamentum suspensorium, and thus reaches the hepatic region. Its two ramifications are, firstly, a branch which joins the portal vein and enters the liver, and, secondly, the ductus Arantii, which empties into the vena cava inferior.

The anatomical structure of these three blood vessels differs from that of all the rest of either arteries or veins. The umbilical arteries are thick and strong, both inside and outside the abdominal cavity; particularly so in the proximity of the umbilicus. Inside the abdominal cavity they are more compact, and of a yellowish red color, outside softer and paler. Their muscular layers are mostly circular, some longitudinal. Where the latter are found, they are external to the former. The muscle extends to the adventitia; its largest size it attains near the umbilicus, inside the abdominal cavity. In the cord the muscular layer of the arteries is very massive betwen adventitia and endothelia. There is *no elastic membrane and no intima*. Some elastic tissue is found near the umbilicus, it gradually increases in the abdominal cavity; but the intima is not developed in the arteries until they are in close proximity to the iliac. Thus, by the massive and powerful

development of the muscular layer, it is explained why there are so few hæmorrhages though no ligature have been applied to the cord.

There are some other peculiarities about the umbilical arteries, viz.: straight, oblique, or irregular prominences, which cannot be made to disappear by stretching, and contain what little elastic tissue is met with in this neighborhood. There are also dilatations of the lumen, which depend upon differences in the thickness of the walls, and longitudinal grooves resulting from occasional local diminution of the amount of muscular tissue. Valves there are none. These dilatations and grooves, however, have nothing to do with the contraction of the arteries, for after death they remain intact and are replete with blood. That contraction is the result of the rigor mortis of the muscular layer and the reflex action produced by the influence of the cooler temperature surrounding the newly-born. Beside these normal peculiarities, anomalies are also noticed. Three cases of inequal development of the umbilical arteries have been reported by Hausmann. In one of them one of the arteries was narrow and terminated inside the pelvis, behind the urinary bladder; but the other, with its hypogastric artery, and even the common iliac, were considerably dilated.

The umbilical vein differs from the arteries very much less than is usual with veins and arteries in any other parts of the body. The muscular layer is very large and strong in the vein. There is *no intima.* None of the three vessels emits branches; there are *no vasa vasorum* and *no nerves* in their walls.

To this marked simplicity of the vessels there is but one exception, viz., in the neighborhood of and round the navel. Some arterial vessels starting from the anterior abdominal wall, bladder, and liver, form a circular anastomosis, known by the name of circulus arteriosus umbilicalis. It is located in the subperitoneal connective tissue and distributed over the adventitia of the intra-abdominal portion of the umbilical arteries. Other branches penetrate the ring and linea alba, send their capillaries to the subcutaneous connective tissue of the umbilicus, and form a fine vascular circle round the umbilicus as far as the starting point of the amnion.*

It is not surprising that blood vessels which have but temporary functions ending with the termination of intra-uterine life should exhibit a structure as different from that of the rest of the blood vessels as their functions are unique. But the facts are not more interesting than those connected with the structure and functions of infantile vessels when compared with those of adults.

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* A. Jacobi, in Gerhardt's Handb. d. Kinderk., 2d ed., I. 2, p. 21, 1882. Strawinsky, the same, I. 1, p. 298.

E. Hofmann* discovered the peculiar fact that the arterial pressure is very small in the newly born animal. It is but 90 mm. in the newly born dog and cannot be raised to more than 160 mm. by suffocation. In the grown dog it amounts to 160 or 180 under ordinary circumstances. Even as large arteries as the carotid, when cut, do not spurt as in the adult. This is another reason why cords not ligated will often not bleed, with the exception of those cases in which the arterial pressure is increased by a moderate degree of asphyxia, or the lungs are not inflated in consequence of incomplete development of the muscular strength in the prematurely born fœtus.

According to a number of actual observations made by R. Thoma, the post-fœtal growth is relatively smallest in the common carotid, and largest in the renal and femoral arteries. Between these two extremes there are found the subclavian, aorta, and pulmonary arteries. These are differences which correspond with the differences in the growth of the several parts of the body supplied by those blood vessels. In regard to the renal artery and the kidney, it has been found that the transverse section of the former grows more rapidly than the volume and weight of the latter. Thus it ought to be expected, that congestive and inflammatory processes in the renal tissue were almost predestined by this disproportion between the size of the artery and the condition of the tissue. Moreover, the resistance to the arterial current offered by the kidney substance depends also upon the readiness with which the current is permitted to pass the capillaries. Now it has been found experimentally, that their permeability is greater, and that within a given time more water proportionately can be squeezed through them, in the adult, than in the child. This anatomical difference may therefore be the reason why renal diseases are so much more frequent in infancy and childhood from all causes, with the exception of that one which is reserved for the last decades of natural life, viz., atheromatous degeneration.

The blood vessels will, however, not exhibit this stationary proportion under all circumstances. In certain constitutional disorders the proportion of heart and blood vessels is found very much changed. As it is not probable that a chronic disorder in its slow progress should work a rapid change in the blood vessels, the inference is a sound one, that, if the disorder cannot have altered the blood vessels, these must have given rise to, or be connected with, the nature of the disorder. For instance, in rhachitis, the heart is of average size, but the arteries are abnormally large. Great width of arteries lowers blood pressure. Thus is best explained the murmur first discovered by Fisher, of Boston, over the open fontanelles of rhachitical babies, very much better

* Oesterr. Jahrb. f. Päd., 1877, p. 189.

indeed than, as Jurasz asserts, by osseous anomalies in the carotid canal. Another result of the low blood pressure is the retardation of the circulation in the muscles, with flabbiness and incompetency as consequences, and still more about the epiphyses which swell and soften. It is very much less the cartilaginous condition of the epiphyses which gives rise to rhachitis, (for some of them do not ossify before the twentieth year or later, at a time when no rhachitis is observed) than some constitutional disorders, of which the principal one may be, as stated, the unusual size of the blood vessels. There are other anomalies in rhachitis which aid in the retardation of circulation, viz., the large size of the liver and the smallness of the lungs. Through all of these sources ossification becomes defective and irregular, the epiphyses exhibit sponge-like softness and hyperæmia first, and hardening, s. c. eburneation of the rhachitical epiphyses afterwards. The latter is a natural consequence of the slow circulation, which results in a local escape of carbonic acid and thereby to a mechanical deposit of phosphate of lime previously kept in solution.

The condition which has been called scrofula exhibits a different condition of the heart. The normal relation of the weight of the heart to that of the lungs, between the second and twentieth year, is 1:5-7; in scrofula it is 1:8-10. That means, the heart is smaller than normal. This circumstance, coupled with an acquired debility of the nervous system, results in an insufficient supply of blood to the lungs, and to the whole body, in defective oxygenization, in œdematous deposits, in general ill-nutrition, and peculiar tendency to disintegration of the tissue of mucous membranes, bones and the skin, mainly in those cases which have been called torpid scrofula by common consent. It is in the latter form in which, by virtue of insufficient circulation, the lymphatic system pre-eminently participates. This is the more important, as the size, patency and number of lymphatics are very great in infancy. Sappey found that they could be more easily injected in the child than in the adult, and the intercommunication between them and the general system is more marked at that, than any other period of life.* These facts have been confirmed by S. L. Schenik who, moreover, found the network of the lymphatics even in the skin of the newly born endowed with open stomata, through which the lymph-ducts can communicate with the neighboring tissue and cells.

It is not necessary, however, to look for *abnormal* constitutional conditions as the results or accompaniments of altered blood vessels. Under normal circumstances, both the length of arteries and their width will change in different periods of life. The common carotid

* Thus the greater tendency during early age to constitutional symptoms in diphtheria, for instance, is easily explained. A Jacobi, Treatise on Diphtheria, p. 31.

has, in the newly born, half the length of the descending aorta, but very much less in more advanced age when the vertebral column increases in length. In other parts of the body the development of arteries proceeds inequally, thus the superior thyroid bends downward to a considerable extent about the period of puberty, while the larynx is becoming larger and the thyroid gland descending. The thoracic also descends from the upper end of the dorsal vertebral column, and the superior intercostal arteries become steeper. All the large arteries are getting enlarged after birth until the twentieth year, after that period the increase is slow, but does not cease altogether before the latest decade of life. Even the veins change considerably in their anatomical structure. There are a hundred valves in the veins of the lower extremities of the newly born, which disappear readily afterwards, though there may be no anomalous retardation of the venous circulation.

The width of the arteries does not depend on their congenital predisposition only,* but also on the degree of blood pressure resulting from changes in the heart. A large or hypertrophied heart increases the size of the arteries; aortic or mitral incompetency renders them gradually smaller. On the other hand, undersize of the arteries produces a hypertrophy of the heart and lowers the circulation and blood pressure, together with insufficient nutrition in the periphery to such an extent as to produce hæmophilia, purpura, or gastric ulcerations in the chlorotic. Still, there are congenital cases in which the abdominal viscera are found perfectly normal when the abdominal arteries are considerably narrower than normal.*

Abnormal smallness of the arteries has attracted the attention of many observers. Lanceraux† describes an aorta which was thin, yellowish and fatty, and had a circumference of only five or six centimetres. Long before him, however, Morgagni and Meckel observed a deficient development of heart and aorta, and Rokitansky‡ found at the same time smallness of the heart, arteries, sexual organs, and body, which he does not look upon as atrophy, but as original hypoplasia, but does not connect with chlorosis. Bamberger§ speaks of small arteries not interfering with the size of the body, but resulting in chlorosis without or with hæmorrhages. Virchow, who has studied the influence of undersized arteries with greater results than anybody, found no constant relation between them, the condition of the body, and the presence or absence of hæmorrhages. The latter have been noticed by Trousseau, who describes the hæmorrhagic form of chlorosis. Virchow found that smallness of arteries may leave the rest of the body now and then intact, and the sexual organs sometimes fully

* G. Fleischmann, Autopsies, 1815.
† Path. Anat. II., p. 842.
‡ I., p. 558; II. 418, 585.
§ Dis. of the Heart, 1857, p. 346.

developed with chlorosis and profuse menstrual flows, sometimes, however, of insufficient development. In that case small ovaries and uterus are combined with chlorosis.

The worst forms of the latter conditions have been found by Virchow, and others since, to depend mainly on the smallness of arteries, no matter whether the heart is also small or of normal or large size. The latter condition may be either congenital or acquired, and depend on either genuine hypertrophy or fatty degeneration. In the latter case the heart is flabby and of loose structure. In all these cases chlorosis may make its appearance very early and independently of sexual life, for Becquerel has the case of a chlorotic child, six years of age, and others which developed after confinement. Or it may exhibit its symptoms about the usual time, and prove incurable through all life because of the permanence of the congenital insufficiency of the blood vessels.

Seé (Lecons de Pathologie Experimentale. Du Sang et des Anémies. Paris, 1867, p. 256,) speaks of hereditary and constitutional chlorosis. Heredity of chlorosis, in either sex, may not show itself at birth. Though not congenital, it may appear between the first few months and the second dentition. After it has been once developed, it clings to the patient through normal and morbid conditions, as an integral part of the general constitution. This hereditary chlorosis is often perceived in the male, from infancy to adult age. In a family in which both grandmother and mother were eminently chlorotic, he observed a girl and two boys, who grew pale in the first few months and long preserved a well-marked discoloration, with functional murmur and all the symptoms of chloro-anæmia. Still, all the time a certain amount of strength and adiposity remained. Bouillaud called such cases of chlorosis constitutional ailments, and Trousseau pronounced them mostly incurable.

Still more dangerous conditions may depend upon congenital smallness of the arteries. I have in my possession pieces of the large arteries, of uncommonly small circumference, and the heart of a little more than normal size and in granular degeneration, that were taken from the body of a lady who died at the age of thirty-two years. She had always been anæmic, suffered from fainting spells during menstruation, which was sometimes interrupted for many weeks, and all the symptoms of thorough anæmia all her lifetime; and finally died, with the diagnosis confirmed by medical men of the highest professional standing, of pernicious "essential" anæmia in consequence of a moderate intestinal catarrh.

Normal growth of the body and its organs depends on active blood supply and vigorous circulation. The presence of blood with but little propelling power may give rise to swelling and congestion and nutritive

disorders, such as rhachitical epiphysitis, but not to healthy increase and function. The size and vigor of the newly born heart offers a ready explanation for the rapid growth of the infant body, and mainly those organs which are in the most direct communication with the heart by straight and fairly large blood vessels. In this condition are the head and brain. Thus the latter has an opportunity to grow from 400 grammes to 800 in one year; after that period its growth becomes less marked. At seven, boys have brains of 1,100; girls, of 1,000 grammes. In more advanced life its weight is relatively less, 1,424 in the male and 1,272 in the female. At the same early period the whole body grows in both length and weight. The original length of 50 centimetres of the newly born increases to 110 with the seventh year, the greatest increase after that time amounts to 60 (in the female 50) centimetres only. In the same time the weight increases from 3.2 kilo. to 20.16 in the boy, from 2.9 to 18.45 in the girl. That gives a proportion of 1 to 6 or 7, while after that time the increase is but three or four fold.

As I have stated, the large blood vessels do not grow equally. At first, the pulmonary artery is from two to four centimetres larger than the ascending aorta. That means for the lungs more active work, but also more tendency to disease, particularly as, since the closure of the ductus Botalli, the aorta which gives off the bronchial arteries, assumes considerable proportions within a short time.

The labor required of both heart and lungs is greater than in the adult; thus fatigue is more easily experienced, and the necessity of sleep, the interruption or absence of which adds to exhaustion and waste, is readily explained. More physiological work is done by these two organs, and, moreover, in a manner somewhat different from what we notice in those fully developed. In these, nothing is required but the substance, or rather constant reproduction of the bulk of the body; in the child, not only reproduction, but a new development of tissues must go on, and perpetual growth. And all this has to be accomplished at the expense of a blood, which, after having been drained of its surplus of solid constituents immediately after life, contains less solid constituents than the blood of the old. Thus the normal oligæmia of the child is in constant danger of increasing from normal physiological processes. The work before a baby has to be performed with, so to speak, a scarcely sufficient capital. The slightest mishap reduces the equilibrium between that capital and the labor to be performed, and the chances for the diminution of the amount of blood in possession of the child are very frequent indeed.

Thus, the vulnerability of the young being great, and diseases in early infancy and childhood so very frequent, cases of anæmia are met

with in every day's practice, and in every form, complicated and uncomplicated, with great emaciation or without it, and either curable or not.

The slowness of the circulation and its insufficiency in all cases where the normal relation between heart and blood vessels is disturbed, as for instance, in rhachitis and the watery condition of the blood, are apt to give rise to catarrh of the pharynx and larynx and the respiratory organs in general. Besides, the walls of the blood vessels are known to suffer in anæmia. They become thin, and undergo fatty degeneration, which Ponfick has found in the heart, and in the intima of the larger blood vessels and in the capillaries. In consequence of the thinness of the blood and the changed condition of the blood vessels, serous transudation, and, now and then, extravasations will take place. The same occurrence is noticed in the adult in conditions of anæmia. It not infrequently occurs that those who have least blood, lose it most easily. Anæmic women are very apt to have copious menstruation, and when their general condition has been improved, both blood and blood vessels resist this tendency to hæmorrhage.

Hæmorrhages, again, result in anæmia in a number of instances. They are of different character and importance. There is true melæna; umbilical hæmorrhage; hæmophilia; primary or secondary purpura; internal hæmorrhages of the newly born; cephalhæmatoma; hæmorrhages from rectal polypi; epistaxis depending on coryza; epistaxis at a more advanced age from heart disease and abdominal stagnation; hæmorrhages in diphtheritic angina; and such as take place during or in consequence of operations for hare-lip or ritual circumcision. Death may result from many of them, such as melæna, hæmophilia, pharyngeal hæmorrhages, or circumcision; others are of but little gravity, such as the sanguineous tumor of the newly born; others are apt to result in permanent ailing. As a rule, however, an acute anæmia is more easily overcome than one that is of a more chronic nature, and thereby undermines the vitality and strength of the organs while it slowly robs them of their nutriment. Infants who are thus stricken recover but slowly or not at all. Young animals resist starvation to a less degree than old ones. A dog of two days bore starvation in Magendie's laboratory but two days; a dog of six years, thirty. Similar results were obtained by Chossat in his experiments on pigeons. Thoroughly anæmic and delicate babies seldom recover entirely, like starving young animals which never attained their normal condition though they were carefully fed afterward.

Even in such instances, however, murmurs in the jugular veins are not very frequent in infancy and early childhood. Murmurs in the carotids and over the large fontenelles, however, are by no means rare.

It is not true that these murmurs, audible over the brain, belong to rhachitis only. They are found in every condition in which the blood pressure in the large arteries of the cranial cavity is lessened.

The heart itself exhibits functional murmurs but seldom. Whenever there are murmurs present, it is safer to attribute them to organic disease rather than to merely functional disorder. In most cases it is not difficult, with the restrictions detailed before, to diagnosticate the consecutive hypertrophy. Besides, it is now well known that acquired endocarditis is by no means rare, and, moreover, that it occurrs even more frequently; for acute articular rheumatism is by no means infrequent in the infant and child. Although the brain be not so liable to suffer from emaciation, dependent upon anæmia, as other organs, still there are a number of cases in which headaches, attacks of syncope, sleepiness, etc., or, on the contrary, sleeplessness and hysterical attacks, are the result of anæmia alone, and disappear when this condition is relieved. Not a few of the babies and children who cry the greater part of the night have no other ailment besides general anæmia, and such children are frequently relieved by a meal or some stimulant before they are put to bed, or given during the interruption of their sleep. The pulse of such children is sometimes very much accelerated; sometimes, however, it is slow, and sometimes irregular. I have known such children, in whom for months, and occasionally for years, I have feared the development of cerebral affections from the very fact that their pulse was both slow and weak and irregular; and yet, when their general condition was improved, both the regularity and the frequency of the pulse were increased.

It is this class of cases which is so frequently neglected by both parents and physicians. If this condition of anæmia and ill-nutrition be allowed to continue, the first attack of an acute febrile or infectious disease will extinguish the light that never burned brightly. What might have been done to avert that calamity, is the question we propose to ourselves when it is too late. There are many indications, of which I mention but one. As the greatest labor of living has to be performed by the heart, which is suffering from ill-nutrition more than the rest of the body because of the hard and constant work to be performed, let the heart be stimulated and strengthened while you attend to the rest of the indications; for the heart stimulants will not only whip the heart into action, they do very much more—they invigorate the circulation in the heart muscle and reinforce it, while they stimulate.

There are blood vessels so thin and incompletely developed, and integuments so poorly formed, that bleeding will now and then make its appearance spontaneously. I remember two such cases, particularly one in which blood would trickle from the surface of the lower

extremities like perspiration, in drops, day after day, until the baby died of exhaustion. That, in babies who die within the first week, or later even, the pericardium and pleura are covered with scores and hundreds of smaller or larger blood points, which give no rise to any prominent symptoms, is not at all uncommon. In all these cases the hæmorrhage need not be the result of a deterioration of the blood vessel tissue by constitutional diseases at all. Of the latter, however, it is principally hereditary syphilis which gives rise to such a hæmorrhagic diathesis. It is in these cases not so much an endocarditis which can be charged, as in advanced age, with the production of hæmorrhages, but the defective general tissue formation and the presence of gummata and white hepatization of the lungs.

Still, endocarditis and atheromatous degeneration are not unheard of in the young. Moutard Martin* reports the case of a boy who died of small-pox at the age of two years. At the autopsy there were found: pericarditis sicca, hypertrophy of the heart, and atheromatous deposits of a diameter of from two to five millimetres, about an inch below the origin of the aorta. Sanné, in an article on the aneurism of the aorta and atheromatous degeneration during infancy,† has four cases of aneurism from that cause, one in a fœtus, and three in children of two, ten, and thirteen years. I have in my possession the descending aorta of a girl who died, at the age of seven years, with an aneurism. After all, however, atheromatous degeneration in the young is but an exceptional occurrence. But ruptures of blood vessels are very frequent, the more so the younger the individual. Congenital thinness of the blood vessels, without atherosis, is by no means rare; a certain grade is the rule. Voigtel refers also to a deficiency of original formation as a probable cause of aneurisms; Cruveilhier‡ refers to cirsoid aneurisms as resulting from congenital thinness of the median layer, and says that now and then arteries and veins cannot be distinguished from each other. Virchow, as related before, explains the worst cases of lifelong chlorosis by the thin walls and narrow lumen of the arterial vessels. Klebs met with thin blood vessels in a dropsical baby that died when thirty-two weeks old. C. O. Weber reports congenital atrophy and weakness of the arterial walls. Balassa claims them as the causes of spontaneous aneurisms; so does Gull in a case of aneurism of the arteria cerebelli; and Dieulafoy describes the case of a girl of seventeen years, in which the cerebral hæmorrhage was due to miliary aneurisms resulting from hereditary predisposition.

As may be inferred from what has been said, the vascular debility may be of two kinds. It may be local, and then give rise to miliary or

* Bull. Soc. Anatom., 1875, p. 775. † Revue Mens. fev., 1887.
‡ Traité, I., p. 735.

larger aneurism; or it may be general, and exist while all the membranes constituting the wall are present.

In the arteries of medium and small calibre, the elastic membrane is a thin and simple membrane; it is only in larger arteries that elastic fibres will also extend into, and mix with, the adjoining layers. The elastic membrane is particularly thin where the branches are given off from the arteries. It is here where spontaneous hæmorrhages are most apt to take place. It is here also where, in later life, aneurisms are found, such as find no ready explanation by an injury. Not only has the elastic membrane been found thin, but entirely absent in such places, and there it is where Eppinger* looks for the seat of what he calls congenital aneurisms; that is, those which, though they make their appearance in later life only, still owe their original source to that congenital anatomical defect.

From the physician's standpoint the combined action of the heart and arteries—the pulse—is particularly interesting.

The pulse of the infant and child offers a great many differences from that of the adult, both in frequency and volume. As already stated, the pulse of the fœtus varies from 124 to 144 or 150 and more. Immediately after birth it is very much less frequent. Within an hour it assumes a certain regularity, and still the figures furnished by a large number of competent authors appear to prove the greatest difficulties in obtaining uniform results. From what I have observed, J. L. Smith is correct in fixing the number of heartbeats in a minute at 136, his lowest figure being 96, his highest 164. According to some, the average figure rises during the second half of the first month, and then proceeds slowly to decrease. From the first to the sixth month the pulse is 120 during sleep, 130 to 135 while awake. It is 100 at six years, 88 at thirteen, 72 in the adult. Tall children exhibit less frequency than short ones; girls, after the fifth year, and more so about puberty, more than boys. The pulse is more rapid in the infant while awake, sitting up, or standing, than while asleep or lying down; more in excitement, exercise, or fever. Thus it is difficult to arrive at a safe estimation of the frequency of the pulse in case of sickness. In the radial artery it is sometimes impossible to obtain it; the femoral or carotid is often more accessible, the basilar, through the open fontanelle, very much more so. When frequency alone is the object of examination, it is always better not to touch the baby at all. The beats of the fontanelle or the carotid can be distinguished and counted easily, up to a frequency of 240 a minute. But it is not always, or not only the frequency we wish to notice, but the character of the pulse. In the latter respect the young have their peculiarities. The expansion of the artery is very much more perceptible and prolonged than the contraction, and the rhythm is by no means

* Langenbeck's Arch., vol. xxxv., Suppl., 1887.

stationary. The pulse is very apt to be irregular, even during the regular respiration of sleep. The slightest deviation from the normal standard of health renders it slightly but perceptibly irregular; anæmia does the same, and either increases or diminishes its frequency. When the latter takes place, the differential diagnosis between anæmia and incipient meningitis, with its pneumogastric irritation, becomes quite difficult.

The examination of the pulse was, in the absence of the modern methods of diagnosticating, which are liable to render us more exact, though less observing and circumspect, a source of study and instruction in ancient times. In Daremberg's "History of Medicine," Paris, 1879, I., p. 224, I find the following remarks quoted from two Greek authors on the pulse of the young. Rufus, of Ephesus, speaks of it as small, and yielding no perceptible difference between diastole and systole. Herophilus calls it *'αλογος*; that is, deprived of sense, or rules, or proportion. It is known to increase in volume with advancing age, and to accommodate itself to metric measurements. That of the newly born is pyrrhic, ∪∪, two short beats; the child, trochaic, —∪, one long and one short beat, with three tempi, two of which belong to the diastole, one to the systole; the adult, spondaic, — — two long beats; senility, iambic, ∪ —, one short and one long beat. Such observations are more than merely interesting through their ingeniousness and poetical flavor; they are correct. It is too seldom that we modern men look for instruction and edification amongst our ancient or more recent predecessors; it is too often that we forget how much we could each of us learn directly from Hippocrates and Celsus, or Sydenham and Peter Frank.

Both the biologist and the practicing physician—I wish they were identical—are interested in the condition of the pulse of the young. Some of its anomalies I have alluded to before. To what extent it will guide us in our diagnosis of incipient meningeal disturbances, every practitioner has experienced many times. In normal children, after the fourth or fifth, certainly after the seventh year, the pulse is regular, rhythmical, and of equal strength. When there is irregularity in strength and rhythm, it proves impaired condition either of the heart or its innervation; and in connection with other symptoms, like those of Josef Hofmann, incipient neurasthenia and physical and intellectual dangers ahead.

In which way it may lead us to a rapid, at least preliminary, diagnosis of inflammatory lung diseases, has not appeared to me to be sufficiently appreciated. At least I find, in my daily rounds, that the proportion of pulse to respiration is not always watched. What I mean is this: the normal relation of heartbeats to the number of respirations

is 37 or 38 to 10. When this relation is disturbed, there is a reason for it. When the number of respirations is increased compared with the pulse, say ten to thirty, twenty-five, or even less, and particularly when the change took place rather suddenly, with fever and all the other signs of an acute disease, there is inflammation of the organs of respiration. Mistakes are very rare. They may be, it is true, the result of an occasional—though very uncommon—*actual* complication with meningitis (I do not speak of the *secondary* meningitis of pneumonia). That may retard the pulse even in a pneumonia, as it does without it; or the mistake may be due to an old heart disease, or unusual degree of cardiac debility, which increases the pulse beyond expectation.

Here, Mr. President, I must finish my remarks. I am aware, and gratefully so, that you have consented to listen to them with forbearing patience, like kind hosts. They have been quite extensive, perhaps too much so; but how fragmentary they were after all, struck me only when I felt they were too prolonged. Still, the subject is one of vast importance and great interest, though its discussion had to be curtailed. I might have drawn many more conclusions based upon the facts touched upon, evolved indications for treatment, and pointed out the way to remedy some of the evils alluded to, and their consequences. I had to omit this, I must say, rather unwillingly; for I do not belong to the class of those who look upon the practice of medicine as inferior to its study, as a trade, as a necessary evil, as a failure, or a placebo. On the contrary, I rejoice in knowing and learning more profoundly and feeling more keenly, from year to year, that there is no nobler aim for even the most abstruse study and abstract science, than their utilization in the service of mankind, and that every intellectual effort, every scientific gain, ought to and finally will, be ennobled by being made subservient to a practical end. That practical end of all investigations and studies of anatomical and physiological questions is the prevention and cure of disease. It is this combination of intellectual labor and practical result, undertaken and accomplished in the interest at the same time of scientific research, and the moral elevation and physical welfare of both the individual and the commonwealth, wherein lies the fascination of our professional calling. None understands and appreciates that better than an academic assembly such as favored me with the invitation to be present to-night, and with the honor of the permission to address them.